9th Grade Student Work

Below is an example of student work from the *Honors Ecology* class, in academic year 2008-09. In this field laboratory investigation, "*Nitrogen Cycling in the Amherst Regional Experimental Forest,*" students measure ammonium and nitrate concentrations to determine the effect of soil moisture on the nitrogen cycle. This subject has major implications for agriculture throughout the world.

This student received an 'A' on her lab report.

Drying the soil affects the nitrogen cycle in the AREF by allowing oxygen to be freely available for nitrification, implying that weather and humans can have huge effects on agriculture.

How would drying the soil affect the nitrogen cycle in the AREF, and what are the implications for Earth's forests? We looked at the effect of water logging on nitrification, and how drying of a waterlogged soil can change the nitrogen cycle of an ecosystem. Using shovels and hands we took two samples of waterlogged soil and one sample of dry, placed the dry and one wet sample in closed bags and the remaining wet in an unsealed bag, and let them sit in the classroom. After a month, the dry soil had 0.117 mg/cm^3 total inorganic N, the dried out soil had 0.049 mg N/cm^3, and the wet soil had 0.038 mg N/cm^3. Nitrification rates will go up in areas that dry out and go down in areas that flood.

(*student name*)

Period

9/26/08

Introduction

The point of this lab was to find how drying the soil affects the nitrogen cycle in AREF, and what this implies for all of Earth's forests. The nitrogen cycle is a system of processes that circulates nitrogen from the atmosphere through the ecosystem and back again. One process involved is ammonification, or N mineralization, where bacteria and fungi break down soil organic matter and release nitrogen in the form of ammonium (NH_4^+). If oxygen is available in the soil, other bacteria will use it to convert NH_4^+ into nitrate (NO_3^-) in the process of nitrification. Ammonium and nitrate are forms of inorganic nitrogen, meaning that they do not contain carbon-hydrogen (C-H) bonds. Our goal was to extract inorganic N to find how saturation of soil affects mineralization and nitrification, and how drying a waterlogged soil changes the nitrogen cycle in an ecosystem. This question is important because it explores the significance of nitrogen for life. Nitrogen is one of the six essential elements for life, and makes up proteins in amino acids and nucleic acids (Dartnell). The nitrogen cycle is vital for sustaining life because it keeps nitrogen available in the environment in forms that organisms can use (Raven). The changes in the nitrogen cycle due to the flooding and drying of soil can be used by farmers to increase the N availability in their soils, thus increasing crop production. Climate change could have a severe effect on the N cycle in some places due to increased precipitation and more frequent hurricanes, decreasing soil oxygen and therefore nitrate production.

Methods

Our sampling site was located in the Amherst Regional Experimental Forest (AREF). This particular section was fairly flat, had many deciduous trees and there were varying degrees of wetness. A small creek held mostly heavily saturated mud, while other portions had drier soil. The samples of soil were taken using hands and a shovel, using the shovel to dig below the surface, and hands to scoop up the soil. Two samples of waterlogged soil and one sample of dry soil were put into separate plastic bags. The dry soil bag and one wet bag were sealed shut, while the other wet soil bag was left open. They were left in the classroom for around a month before the experiment took place. In the experiment, we used a digital balance to weigh the mass of the extraction sample plus tare (11.4 g), the moisture sample plus tare (12 g), and the dried moisture sample plus tare (6.7 g). We used a color wheel to measure the concentration (0.46 mg/L) of nitrate N in the extract and a graduated cylinder to measure out 100 ml of potassium chloride (KCl). After making our calculations and compiling the results of all the classes, we represented our data as a stacked bar graph. The x-axis was soil type, and the y-axis was the total mg N/g soil, broken into ammonium on the bottom and nitrate on the top.

Results

Soil N Data 2008 (all values mg N/g soil)

	Dry	Dried Out	Wet
NH_4^+	0.085	0.039	0.037
NO_3^-	0.032	0.010	0.001

Calculations

$(0.46 \text{ mg N/L})(.1 \text{ L}) = 0.046 \text{ mg N}$

$11.4 \text{ g } (M_W + T) – 1.6 \text{ g } (T) = 9.8 \text{ g } (M_w)$

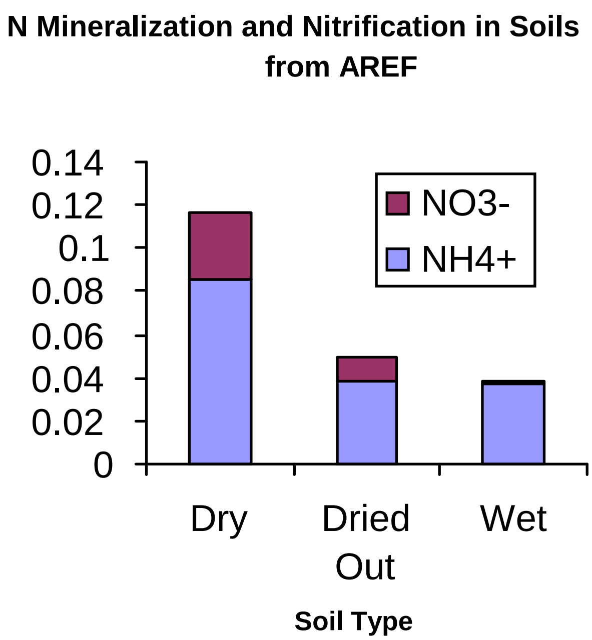
$12 \text{ g } (M_W + T) – 1.3 \text{ g } (T) = 10.7 \text{ g } (M_w)$

$6.7 \text{ g } (M_D + T) – 1.3 \text{ g } (T) = 5.4 \text{ g } (M_D)$

$5.4 \text{ g } (M_D) / 10.7 \text{ g } (M_w) = 0.51 \text{ g } M_D/ \text{ g } M_w$

$(9.8 \text{ g } M_W)(0.51 \text{ g } M_D/ \text{ g } M_w) = 4.9 \text{ g } M_D$

$0.46 \text{ mg N } / 4.9 \text{ g } M_D = 0.094 \text{ mg N/ g soil}$



The three soils varied in inorganic N, with the most in dry (0.117 mg/g) the next in dried out (0.049 mg/g) and the least in wet (0.038 mg/g). The dry soil had 0.085 mg/g ammonium and 0.032 mg/g nitrate. The concentration of ammonium was very similar in the dried out and the wet soil, at 0.039 mg/g and 0.037 mg/g respectively. The dried out soil had 0.010 mg N/g as nitrate while the waterlogged soil had almost none, with 0.001 mg N/g. The graph shows us that the less water is in a flooded soil, the more nitrate is present, and that drying the wet soil increased the amount of nitrate. The dry soil had more ammonium, but drying the wet soil did not change the ammonium content very much.

Discussion

In the Amherst Regional Experimental Forest, dry soil had 0.032 mg/g nitrate and wet soil had only 0.001 mg/g nitrate after one month of storage. If the AREF got enough rain to flood it completely, the soil would produce less nitrate. Our experimental treatment of drying the wet soil increased nitrate from 0.001 to 0.010 mg/g. If a farmer cleared the land and mixed and turned the soil, oxygen would permeate the gaps in the soil, thus increasing the nitrification rate.

Our results agree with the idea that oxygen is needed for nitrification (Raven). Also, our results might suggest that if a dry soil containing a lot of nitrate was flooded, some nitrate could be lost in denitrification (Raven).

Uncertainty in our measurements came from the use of a color wheel to estimate the amount of nitrate (4.6 mg N/L) because it was difficult to match the colors exactly. Also, we used different soil samples for the dry and wet weights, and the soil water, organic matter, or nitrogen content of the soil itself could differ slightly, affecting the dry to wet ratio (g/g) and N mineralization (mg N/g soil). A third source of uncertainty is the fact that the wet soil samples that were dried may have dried out to different degrees affecting the oxygen supply, and thus the rate of N mineralization (mg N/g soil).

The implications of this experiment span the whole Earth. Extreme periods of rain or droughts would change soil water content, and therefore affect the rate of mineralization and nitrification. This pattern also suggests that rainforests and swamps have much less nitrate than grasslands and temperate, deciduous forests. Finally, farmers who drain saturated soil can reap the benefits of increased crop yields from the nitrogen release from organic matter. This nutrient source would not be indefinitely sustainable because the nitrogen stored by the flooded soil would eventually run out.